VALVE DRIVING DEVICE FOR ENGINE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a valve driving device for an engine, and more specifically to a valve driving device equipped with a variable valve timing mechanism capable of changing a rotational phase of a camshaft with respect to a crankshaft of an engine.

[0002] Recently, engines for vehicles have been equipped with a valve driving device for changing valve timing (open and/or close timing) of an intake valve and/or an exhaust valve to increase engine power, improve gas mileage and so on. In general, the valve driving device includes a hydraulic (oil) pressure operating type of variable valve timing mechanism operative to change valve timing by changing a rotational phase of a camshaft with respect to a crankshaft of the engine. An example of such mechanism is disclosed in Japanese Patent Laid-Open Publication No. 11-280414.

[0003] In a variable valve timing mechanism disclosed in the above-described publication, a rotor is fixed to one end of an intake camshaft and a housing (casing) is fixed to a sprocket (pulley) which is attached so as to be relatively rotatable with respect to the intake camshaft. Further, the rotor and the housing jointly form a hydraulic (oil) pressure chamber for advance timing (a pressure receiving chamber at advance timing side) and a hydraulic (oil) pressure chamber for delay timing (a pressure receiving chamber at delay timing side). When a hydraulic (oil) pressure control valve for controlling a supply of operating hydraulic (oil) pressure allows the operating hydraulic pressure to act on the hydraulic pressure chamber for advance timing, the rotor is rotated slightly with respect to the housing in a rotational direction of the intake camshaft. As a result, the valve timing of the intake valve advances. On the other hand, when the hydraulic pressure control valve allows the operating hydraulic pressure to act on the hydraulic pressure chamber for delay timing, the rotor is rotated with respect to the housing in an opposite direction to the rotation

of the intake camshaft. As a result, the valve timing of the intake valve delays.

[0004] Further, a sensor rotor (sensing plate) is attached to the intake camshaft and a rotational angle sensor (cam-angle sensor) is disposed close to the sensor rotor. The rotational angle sensor detects a rotational phase of the intake camshaft, i.e., valve timing of the intake valve.

[0005] Such rotational angle sensor includes a detecting end surface. In general, since the detecting end surface of the sensor is located inside of a cylinder head cover of the engine, mists of lubricant oil splashed in the cylinder head adhere on the detecting surface of the sensor. Meanwhile, particulates, such as metal particulates generated by metal parts contacting each other and sworn off, get mixed in the lubricant oil. Most particulates are trapped by an oil filter and the like and then took out of the lubricant oil. However, some particulates remain in the lubricant oil without being trapped, and those particulates may accumulate on the detecting end surface of the sensor. This may cause a problem that the detecting end surface of the rotational angle sensor is covered inappropriately with such particulates, result in deterioration of detecting accuracy of the sensor.

SUMMARY OF THE INVENTION

[0006] The present invention has been devised in view of the above-described problems, and an object of the present invention is to provide a valve driving device for an engine that maintains properly detecting accuracy of a rotational sensor disposed close to a camshaft.

[0007] In order to achieve the above-described object, the first aspect of the present invention provides a valve driving device for an engine, comprising a variable valve timing mechanism disposed at an end portion of a camshaft driving an intake valve and/or an exhaust valve synchronously with a crankshaft of the engine, the variable valve timing mechanism being a hydraulic-pressure operating type of variable valve timing mechanism that is capable of changing a rotational phase of the camshaft with respect to the crankshaft,

a hydraulic pressure control valve operative to control a supply of an operating hydraulic pressure to the variable valve timing mechanism, a rotational angle sensor operative to detect a rotational angle of the camshaft, the rotational angle sensor being a solenoid-pickup type of sensor and including a detecting end surface that is disposed close to a rotational area of a sensor rotor attached to the camshaft. Herein, the hydraulic pressure control valve includes a drain hole, return oil from the variable valve timing mechanism is discharged through the drain hole of the hydraulic pressure control valve, and the rotational angle sensor and the hydraulic pressure control valve are disposed such that the detecting end surface of the rotational angle sensor is located in a spray area of the return oil discharged through the drain hole.

[0008] While the variable valve timing mechanism changes a rotational phase of the camshaft, the return oil is discharged through the drain hole of the hydraulic pressure control valve. According to the valve driving device of the first aspect of the invention, the discharged return oil can be directed toward the detecting end surface of the rotational angle sensor. Accordingly, the detecting end surface can be prevented from being covered inappropriately with the metal particulates or the like, thereby maintaining properly detecting accuracy of the rotational sensor without any other particular measures.

[0009] The second aspect of the present invention provides the valve driving device for an engine of the first aspect of the invention, wherein the hydraulic pressure control valve further includes a spool, a holder for retaining the spool and a solenoid for driving the spool, and the drain hole is formed at the holder.

[0010] According to the valve driving device of the second aspect of the invention, the first aspect of the invention is further materialized for the hydraulic pressure control valve and the drain hole. Further, for example, it may be possible to have a cam cap, which supports the camshaft from above, function as the holder. In this case, the device may have the advantage of a simple structure with small-number parts and compactness.

[0011] The third aspect of the present invention provides the valve driving device for an engine of the first aspect of the invention, wherein the rotational angle sensor is attached to a portion of a cylinder head cover that is close to the hydraulic pressure control valve.

[0012] According to the valve driving device of the third aspect of the invention, since it is relatively easy to attach some parts to the cylinder head cover, this can improve flexibility of selection or adjustability of attaching place for the rotational angle sensor. Further, the close location of the rotational angle sensor with respect to the hydraulic pressure control valve can assure the washing function of the detecting end surface of the rotational angle sensor by the return oil.

[0013] The fourth aspect of the present invention provides the valve driving device for an engine of the second aspect of the invention, wherein the hydraulic pressure control valve is disposed such that an axis of the spool thereof extents substantially in a vertical direction of the engine.

[0014] In general, the drain hole of the hydraulic pressure control valve is configured so as to be flat shaped, having its long axis perpendicular to the axis of the spool. Accordingly, a spray of the return oil discharged through the drain hole spreads in a horizontal direction. Thus, according to the valve driving device of the fourth aspect of the invention, it can be relatively easy for the detecting end surface of the rotational angle sensor to be located in the return oil's spray area spread in the horizontal direction with its close position to the sensor rotor, thereby improving flexibility of its location. Since generally it would be preferred from designing stand point to have more flexibility in the horizontal direction than that in the vertical direction for parts of the engine, the above-described disposition of the hydraulic pressure control valve is meaningful.

[0015] The fifth aspect of the present invention provides the valve driving device for an engine of the first aspect of the invention, wherein the rotational angle sensor is disposed so as to locate close to and at the front of the drain hole of the hydraulic pressure

control valve with respect to a rotational direction of the camshaft.

[0016] According to the valve driving device of the fifth aspect of the invention, the return oil discharged through the drain hole of the hydraulic pressure control valve can be positively carried toward the rotational angle sensor by the rotation of the sensor rotor attached to the exhaust camshaft. As a result, the amount of oil carried to the detecting end surface increases. Thus, it can promote washing of the detecting end surface of the rotational angle sensor by the return oil.

[0017] The sixth aspect of the present invention provides valve driving device for an engine, comprising a variable valve timing mechanism disposed at an end portion of a camshaft driving an intake valve and/or an exhaust valve synchronously with a crankshaft of the engine, the variable valve timing mechanism being a hydraulic-pressure operating type of variable valve timing mechanism that is capable of changing a rotational phase of the camshaft with respect to the crankshaft, a hydraulic pressure control valve operative to control a supply of an operating hydraulic pressure to the variable valve timing mechanism, the hydraulic pressure control valve including a spool, a holder for retaining the spool and a solenoid for driving the spool, a rotational angle sensor operative to detect a rotational angle of the camshaft, the rotational angle sensor being a solenoid-pickup type of sensor and including a detecting end surface that is disposed close to a rotational area of a sensor rotor attached to the camshaft. Herein, the hydraulic pressure control valve further includes a drain hole that is formed at the holder, return oil from the variable valve timing mechanism is discharged through the drain hole of the hydraulic pressure control valve, and the rotational angle sensor and the hydraulic pressure control valve are disposed close to each other such that a spray of the return oil discharged through the drain hole is directed toward the detecting end surface of the rotational angle sensor.

[0018] According to the valve driving device of the sixth aspect of the invention, substantially the same functions and effects as the above-described first aspect of the invention can be obtained.

[0019] The seventh aspect of the present invention provides the valve driving device for an engine of the sixth aspect of the invention, wherein the rotational angle sensor is attached to a portion of a cylinder head cover that is close to the hydraulic pressure control valve.

[0020] The eighth aspect of the present invention provides the valve driving device for an engine of the sixth aspect of the invention, wherein the hydraulic pressure control valve is disposed such that an axis of the spool thereof extents substantially in a vertical direction of the engine.

[0021] The ninth aspect of the present invention provides the valve driving device for an engine of the sixth aspect of the invention, wherein the rotational angle sensor is disposed so as to locate close to and at the front of the drain hole of the hydraulic pressure control valve with respect to a rotational direction of the camshaft.

[0022] According to the valve driving device of the seventh though ninth aspects of the invention, substantially the same functions and effects as the above-described third through fifth aspects of the invention can be obtained respectively.

[0023] The tenth aspect of the present invention provides the valve driving device for an engine of the sixth aspect of the invention, wherein the holder of the hydraulic pressure control valve is formed of a cam cap that supports the camshaft rotatably together with a cylinder head of the engine.

[0024] According to the valve driving device of the tenth aspect of the invention, since the cam cap is used so as to function as the holder for retaining the spool of the hydraulic pressure control valve, this can provide the advantage of a simple structure with small-number parts and compactness.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Other features, aspects, and advantages of the present invention will become apparent from the following description of the present invention which refers to the

accompanying drawings.

[0026] FIG. **1** is a plan view for showing an essential part of a valve driving device for an engine according to a preferred embodiment of the present invention.

[0027] FIG. **2** is a side view for showing part of the valve driving device, where a variable valve timing mechanism is located.

[0028] FIG. **3** is a sectional view taken on line A-A of FIG. **2**.

[0029] FIG. **4** is a partial sectional view of a hydraulic (oil) pressure control valve.

[0030] FIG. **5** is a partial enlarged view for illustrating positional relationships of a sensor rotor, a rotational angle sensor and the hydraulic pressure control valve, when viewed from line B-B of FIG. **2**.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Hereinafter, a valve driving device for an engine according to a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

[0032] As shown in FIG. **1**, an engine **1** is provided with an intake camshaft **4** and an exhaust camshaft **5**, which are disposed in parallel to a crankshaft of the engine (not shown in any drawing) and rotatably supported by both of a cylinder head **2** located below and a cam cap **3** located above. An endless chain **8** is provided so as to be wound round sprockets **6**, **7** attached to the camshafts **4**, **5** and a sprocket (not shown in any drawing) attached to the crankshaft of the engine.

[0033] Accordingly, both the sprockets **6**, **7**, and thereby both the camshafts **4**, **5** rotate synchronously with the crankshaft, so that a plurality of cams **9**...**9**, **10**...**10** (two of cams shown each in the drawing) fixed to each camshafts **4**, **5** respectively can drive a plurality of intake and exhaust valves **11**...**11**, **12**...**12** (two of valves shown each in the drawing).

[0034] Further, the engine **1** is provided with a valve driving device for changing valve timing (open and/or close timing) of the exhaust valves **12**...**12** which includes a variable valve timing mechanism **13**. Specifically, the sprocket **7** is assembled to the exhaust camshaft **5** so that it can be relatively movable with respect to the camshaft **5** within a certain range, and there is provided a hydraulic (oil) pressure operating type of variable valve timing mechanism **13** at an sprocket **7** side end of the exhaust camshaft **5**. The variable valve timing mechanism **13** is capable of changing a rotational phase of the camshaft **5** with respect to the crankshaft of the engine. Further, a hydraulic (oil) pressure control valve **14** for controlling a supply of an operating hydraulic (oil) pressure to the variable valve timing mechanism **13** is attached on the cam cap **3**.

[0035] In the present embodiment, the variable valve timing mechanism **13** may use any known structures. Therefore, only schematic structure thereof will be described hereinafter. As shown in FIG. **2**, the variable valve timing mechanism **13** comprises a hollow housing **21** having four projections (not shown in any drawing) projecting toward its center and a lid **22** covering an one-side opening of the housing **21**. These housing **21** and lid **22** are fixed to the sprocket **7** rigidly through a plurality of bolts **23**...**23** (only two of bolts shown in the drawing). The variable valve timing mechanism **13** further comprises a rotor **24** which is located in the housing **21** and includes four projections (not shown in any drawing) projecting radially. The projections of the rotor **24** are capable of contacting the above-described projections of the housing **21**. The rotor **24** is fixed to the exhaust camshaft **5** rigidly through a bolt **25**. Herein, a space enclosed by the sprocket **7**, housing **21**, rotor **24** and lid **22** is divided into four of hydraulic (oil) pressure chambers for advance timing and the same number of hydraulic (oil) pressure chambers for delay timing, not shown in any drawings, by corresponding projections of the housing **21** and rotor **24**.

[0036] Herein, when the operating hydraulic pressure derived from a hydraulic (oil) source (not shown in any drawing) is supplied to the hydraulic pressure chamber for advance timing, the rotor **24** is rotated in the rotational direction of the exhaust camshaft **5**

with respect to the housing **21** until the projections of the rotor **24** contacts the corresponding projections of the housing **21**. As a result, the rotational phase of the exhaust cam shaft **5** with respect to the crankshaft is changed so as to be advanced, namely, the valve timing of the exhaust valves **12**...**12** advances. On the other hand, when the operating hydraulic pressure is supplied to the hydraulic pressure chamber for delay timing, the rotor **24** is rotated in a direction opposite to the rotational direction of the exhaust camshaft **5** with respect to the housing **21** until the projections of the rotor **24** contacts the projections of the housing **21**. As a result, the rotational phase of the exhaust cam shaft **5** with respect to the crankshaft is changed so as to be delayed, namely, the valve timing of the exhaust valves **12**...**12** delays.

[0037] Next, the hydraulic pressure control valve **14**, which the valve driving device of the engine **1** is equipped with and controls the supply of the operating hydraulic pressure to the variable valve timing mechanism **13**, will be described.

[0038] As shown in FIGS. **1** to **3**, the hydraulic pressure control valve **14** is attached on the cam cap **3** through a bracket **31** by a bolt **32** and disposed such that an axis of the control valve **14** extents substantially in a vertical direction of the engine. The cam cap **3** is fastened by a plurality of bolts **33**...**33** on an upper face of an end portion of the cylinder head **2** located at a side of the variable valve timing mechanism **13**.

[0039] As shown in FIG. **4**, the hydraulic pressure control valve **14** includes a spool 34 with a longer length in its axis direction, a hollow case **35** for containing the spool **34** therein, a solenoid **36** for driving the spool in its axis direction which is located in a base portion (located above in the drawing) of the case **35**, and a spring **37** for pushing the spool **34** against the base portion of the case **35** which is disposed in an end portion (located below in the drawing) of the case **35**. The solenoid **36** includes a coil **38** and a plunger **39** coupled to a base portion of the spool **34**.

[0040] Further, the case **35** is provided with two outlet ports **35a**, **35b** at one side (at the right side in the drawing) with respect to an axis thereof, which are disposed along a

vertical direction of the axis at a certain distance. The case **35** is also provided with one inlet port **35c** and two drain ports **35d**, **35e** at the other side (at the left side in the drawing), which are disposed along the vertical direction of the axis at certain distances in such a manner that the inlet port **35c** is located between the two drain ports **35d**, **35e**. Each of these ports **35a** - **35e** is flat shaped, having its long axis perpendicular to the axis of the spool **34**. The hydraulic pressure control valve **14** is configured such that when the solenoid **36** receives a control signal from an engine control unit or the like (not shown in any drawing), a position of the spool **34** is adjusted accurately by a duty control within the case **35** based on a movement of the plunger **39**, thereby controlling a flow rate and/or a flow direction of the operating hydraulic pressure to be applied to the variable valve timing mechanism **13**.

[0041] On the other hand, the cam cap **3**, which functions as a holder for retaining the spool **34** of the hydraulic pressure control valve **14**, is provided with an insert hole **3'** for receiving the hydraulic pressure control valve **14**, which contains the case **35** of the hydraulic pressure control valve **14** therein. Further, the cam cap **3** includes a hydraulic (oil) pressure supply passage **3c**, a hydraulic (oil) pressure passage for advance timing **3a**, and a hydraulic (oil) pressure passage for delay timing **3b**, which are respectively connected to the above-described inlet port **35c**, outlet ports **35a**, **35b**. Further, as shown FIGS. **2** and **3**, the cam cap **3** is provided with a drain hole **3e** which is connected to the lower drain port **35e**, penetrating the cam cap **3** toward a side where the exhaust camshaft **5** is located. The drain hole **3e** is flat shaped, corresponding to the above-described drain port **35e**.

[0042] Further, as shown in FIG. **2**, the cam cap **3** includes two circumferential grooves **3a'**, **3b'**. These circumferential grooves **3a'**, **3b'** constitute respectively part of the above-described hydraulic pressure passage for advance timing **3a** and hydraulic pressure passage for delay timing **3b**.

[0043] Accordingly, as shown in FIG. **4**, for example, when the solenoid **36** is in a non-active state, the spool **34** takes a position where the inlet port **35c** is connected to the

upper outlet port **35a** and the lower outlet port **35b** is connected to the lower drain port **35e**. Herein, the operating hydraulic pressure supplied to the inlet port **35c** from the hydraulic pressure supply passage **3c** is supplied from the upper outlet port **35a** to the hydraulic pressure chamber for advance timing of the variable valve timing mechanism **13** through the hydraulic pressure passage for advance timing **3a**, the circumferential groove **3a'** and the like. Meanwhile, the hydraulic pressure in the hydraulic pressure chamber for delay timing of the variable valve timing mechanism **13** is drained from the drain hole **3e** leading to the lower drain port **35e** connected to the lower outlet port **35b** through the circumferential groove **3b'**, the hydraulic pressure passage for delay timing **3b** and the like.

[0044] On the other hand, for example, when the solenoid **36** is in an active state, the spool **34** moves downward against the spring **37** to a position where the inlet port **35c** is connected to the lower outlet port **35b** and the upper outlet port **35a** is connected to the upper drain port **35d**. Herein, the operating hydraulic pressure supplied to the inlet port **35c** from the hydraulic pressure supply passage **3c** is supplied from the lower outlet port **35b** to the hydraulic pressure chamber for delay timing of the variable valve timing mechanism **13** through the hydraulic pressure passage for delay timing **3b**, the circumferential groove **3b'** and the like. Meanwhile, the hydraulic pressure in the hydraulic pressure chamber for advance timing of the variable valve timing mechanism **13** is drained from the upper drain port **35d** connected to the upper outlet port **35a** through the circumferential groove **3a'**, the hydraulic pressure passage for advance timing **3a** and the like.

[0045] Next, a rotational angle detecting mechanism for detecting a rotational angle of the exhaust camshaft **5**, with which the valve driving device of the engine **1** is equipped, will be described.

[0046] As shown in FIGS. **2** and **3**, the rotational angle detecting mechanism **41** comprises a sensor rotor **42**, which is attached to the exhaust camshaft **5** relatively close to the cam cap **3**, and a solenoid-pickup type of rotational angle sensor **43**, an detecting end

surface **43a** of which is disposed close to a rotational area of the sensor rotor **42** rotating in an arrow **a** direction shown in the drawing. The rotational phase of the exhaust camshaft **5** with respect to the crankshaft of the engine **1** is determined based on the rotational angle of the exhaust cam camshaft **5** detected by the rotational angle sensor **43** and the rotational angle of the crankshaft detected by an another rotational angle sensor provided for the crankshaft (not shown in any drawing).

[0047] The sensor rotor **42** is of a substantially disc shape, having six projections **42a**...**42a** which are formed on its circumference. Herein, there is provided a substantially 90-degree phase difference between positions of two sets of projections **42a**...**42a**. Namely, there are provided one set of projections **42a**...**42a** comprising one specified projection **42a** and two projections **42a**, **42a** which are located at the opposite side to the specified projection **42a** with respect to the exhaust camshaft **5**, and the other set of projections **42a**...**42a** having substantially the same number and shape of projections of the above-described one set, but being located at positions of 90-degree phase advanced or delayed from positions of the above-described one set.

[0048] Meanwhile, the rotational angle sensor **43** is attached by a bolt **45** through an attaching member **44** to a portion of an upper wall of a cylinder head cover **2a** covering the cylinder head **2** which is close to the hydraulic pressure control valve **14**, in such a manner that its detecting end surface **43a** faces toward the sensor rotor **42**. The rotational angle sensor **43** is configured so as to generate pulse detecting signals when the detecting end surface **43a** comes close to the projections **42a**...**42a** of the sensor rotor **42**.

[0049] Further, as shown in FIG. **5**, the detecting end surface **43a** (illustrated as the one facing toward back in the drawing) of the rotational angle sensor **43** disposed close to the sensor rotor **42** is located in a spray area **S**, shown by two-dotted broken lines, of the return oil discharged through the drain hole **3e** formed at the cam cap **3**, which flows down through the lower drain port **35e** of the hydraulic pressure control valve **14** from the variable valve timing mechanism **13** (see also FIGS. **2** and **3**). Further, the detecting end

surface **43a** is located forward in the rotational direction, shown as the arrow **a**, of the sensor rotor **42**, or the exhaust camshaft **5** (see FIGS. **2** and **3** as well).

[0050] Herein, the function of the valve driving device according to the present embodiment will be described.

[0051] The rotational angle sensor **43** and the hydraulic pressure control valve **14** are disposed such that the detecting end surface **43a** of the rotational angle sensor **43**, which is located close to the sensor rotor **42** attached to the exhaust camshaft **5**, is located in the spray area **S** of the return oil which comes down from the variable valve timing mechanism **13** through the lower drain port **35e** of the hydraulic pressure control valve **14** on the cam cap **3** and is discharged through the drain hole **3e** formed at the cam cap **3**. Accordingly, every time the variable valve timing mechanism **13** changes the rotational phase of the exhaust camshaft **5** to an advanced one, the return oil from the variable valve timing mechanism **13** which is discharged through the lower drain port **35e** connected to the lower outlet port **35b** of the hydraulic pressure control valve **14** by way of the circumferential groove **3b'** and the hydraulic pressure passage for delay timing **3b** and the like from the hydraulic pressure chamber for delay timing is sprayed from the drain hole **3e** formed at the cam cap **3** toward the detecting end surface **43a** of the rotational angle sensor **43**. Namely, the return oil can wash properly the detecting end surface **43a** of the rotational detecting sensor **43** each time. Accordingly, the detecting end surface **43a** can be prevented from being covered inappropriately with the metal particulates or the like, thereby maintaining properly detecting accuracy of the rotational sensor **43** without any other particular measures.

[0052] Further, as shown in FIGS. **2**, **3** and **5**, the rotational angle sensor **43** is attached to the upper wall of the cylinder head cover **2a** close to the hydraulic pressure control valve **14**. In general, it would be relatively easy to attach some parts to the cylinder head cover **2a**. Therefore, this could improve flexibility of selection or adjustability of attaching place for the rotational angle sensor **43**. Further, the close location of the

rotational angle sensor **43** with respect to the hydraulic pressure control valve **14** can assure the above-described washing function of the detecting end surface **43a** of the rotational angle sensor **43** by the return oil.

[0053] Further, the hydraulic pressure control valve **14** is attached on the cam cap **3** such that the axis of the spool **34** extents substantially in the vertical direction of the engine, and the lower drain port **35e** of the hydraulic pressure control valve **14** and the drain hole **3e** of the cam cap **3** are flat shaped, having their long axes perpendicular to the axis of the spool **34**. Accordingly, as shown in the two-dotted broken lines in FIG. **5**, the spray of the return oil discharged through the drain hole **3e** leading to the drain port **35e** spreads in a horizontal direction. Thus, it can be relatively easy for the detecting end surface **43a** of the rotational angle sensor **43** to be located in the return oil's spray area spread in the horizontal direction with its close position to the sensor rotor **42**, thereby improving flexibility of its location. Since generally it would be preferred from designing stand point to have more flexibility in the horizontal direction than that in the vertical direction for parts of the engine **1**, the above-described disposition of the hydraulic pressure control valve **14** is meaningful.

[0054] Further, since the cam cap **3** is used so as to function as the holder for retaining the hydraulic pressure control valve **14**, or spool **34**, this embodiment has the advantage of a simple structure with small-number parts and compactness.

[0055] Further, the detecting end surface **43a** of the rotational angle sensor **43** is located forward in the rotational direction, shown as the arrow **a** of FIGS. **2**, **3** and **5**, of the sensor rotor **42**, or the exhaust camshaft **5**. Accordingly, the return oil discharged through the drain hole **3e** of the cam cap **3** by way of the lower drain port **35e** of the hydraulic pressure control valve **14** can be positively carried toward the rotational angle sensor **43** by the rotation of the sensor rotor **42** or the projections **42a**...**42a**, which are attached to the exhaust camshaft **5**. As a result, the amount of oil carried to the detecting end surface **43a** increases. Thus, it can promote washing of the detecting end surface **43a** of the rotational angle sensor **43** by the return oil.

[0056] Herein, although it is configured such that the cam cap **3** functions as the holder for retaining the hydraulic pressure control valve **14**, or spool **34** in the present embodiment, an additional member different from the cam cap **3** may be used as the holder.

[0057] Further, although the hydraulic pressure control valve **14** is disposed such that the axis of the spool **34** extents substantially in the vertical direction of the engine in the present embodiment, the disposition of the hydraulic pressure control valve **14** should not be limited to this. According to design needs or the like, some modified disposition of the hydraulic pressure control valve **14** may be used within the scope of the present invention. That is, it may be disposed, for example, such that the axis of the spool **34** extends in a lateral direction or a inclined direction of the engine.

[0058] Further, although there are provided the variable valve timing mechanism **13**, the hydraulic pressure control valve **14**, the rotational angle detecting mechanism **41** and the like at the exhaust camshaft **5** in the present embodiment, there may be provided these devices at the intake camshaft **4**. In this case, of course, the same functions and effects described above can be obtained.

[0059] Any other additional modifications may be applied within the scope of the present invention.